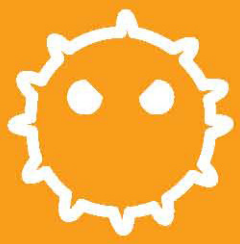

Microorganisms and food

in food quality

Education and Culture
Lifelong learning programme
LEONARDO DA VINCI

1 Microorganisms and food

General Objectives	-Identify the different types of dangers; - Recognize the importance of environmental and other occurring factors regarding food safety and hygiene risks.

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Microorganisms and food

Microorganisms have great importance and impact on our lives, but not always in a pleasant way. They are fundamental for obtaining some food products, but are also the main cause of most cases of food and cultivar deterioration. Aside from this, they also play an important role in food poisoning, as they are the main cause of outbreaks and referenced situations. There are many factors that influence the growth of microorganisms in foods, if they do not produce the same effect on the growth of microorganisms, they all must be considered when trying to prevent the occurrence of food intoxications. There are many types of microorganisms of different forms and more or less complex structures. Bacteria, molds, and yeasts are, among all, those that generally have a greater impact on food deterioration. In what concerns foodborne illnesses bacteria are without doubt the main agents. Many factors contribute to the presence of microorganisms in foods, the endogenous presence and cross contaminations are the factors most pointed out as being "sources" of microorganism in foods. If we add nutrients (these exist in all foods), time and inadequate storage temperatures to the contamination, we are in the presence of all favourable conditions for microorganisms to grow and dwell on the foods, causing by its ingestion, or with the ingestion of toxins, typical symptoms of various types of foodborne intoxications. However, and according to what was referred in the "Costs and implications of food safety flaws" chapter, microorganisms are not the only cause for foodborne illnesses nor are they the only existing hazard. Chemical substances (dioxins, lead, insecticides, etc.), physical substances (pieces of glass, metal and bones, etc.), as well excess substances (salt, fat, etc.) also cause hazards to the consumer.

1 Microorganisms. What are they?

We've all heard about microorganisms or using a more common term, microbes. But what are they after all?

These two terms apply to **all living beings that are not visible to the naked eye,** it is necessary to use special equipment to enable us to see them. This instrument is the microscope. The microscope is nothing more than a set of more or less complex objective lens that allow us to see objects whose size is in micrometers (1um = 0,001 mm = 0,0 001 cm = 0,000 001 m). With this instrument it is possible to obtain amplified images of the observed objects (figure 1).

So, what is a living being? From a biology point of view, a living being is an organism that has the following characteristics:

- Is a made up of a cells;
- Grows and develops;
- Responds to stimuli from the environment;
- Reproduces (with exception to some living being such as the mule).

The **cell** is a structural and functional unit of living organisms. It represents the smallest portion of living matter with an independent ability to self-duplicate.
Like so, there are living beings made up of only one cell – unicellular – like yeasts and bacteria, and others that are made up of billions of cells – multicellular – like humans.

Generally, microorganisms are of great importance in our lives. It is difficult to dissociate some daily gestures/habits to the absence of microorganisms. During our meals we ingest foods in which microorganism have or had a fundamental action – yogurt, cheese, bread, etc; beverages that without the action of microorganisms would not exist – beer, wine, cacao, etc. Then we need medication, food supplements, detergents… and in all these daily use products microorganisms exert a direct or indirect action. They are fundamental for good functioning of the human digestive system, being responsible for the fermentations that take place and responsible for producing some essential vitamins for our organism. But they don't only exist to facilitate our lives. They are also responsible for a lot of our illnesses (for example: cavities that result form the presence of

microorganisms in the oral cavity). Foodborne illnesses are in most cases originated by microorganisms. They are also the main cause of deterioration of food and food products. How many times do we find a spoiled piece of meat or leftovers in the refrigerator?
What is the alteration due to?

What factors make that happen?

To answer these questions it is convenient to know a little bit about microbial growth and about factors that influence that growth.

2 Microbial growth

When we talk about microbial growth, we understand that it has to do with an increase of the number of cells.
Growth rate is greater when all conditions are optimized and any alteration on these conditions will reflect on the growth rate (figure 2). Greater growth rate on a certain food means greater nutrient intake, which in turn, implicates greater alterations.

So generally, it becomes evident that food deterioration is partly related to microbial growth and to the effect on foods. However, microorganisms do not limit themselves to using (consuming) nutrients in food products. Here they are going to produce and modify the present composts, resulting in alterations that are indicators of deterioration. The presence of mucous, odours, aromas and abnormal tastes, are some consequences of microbial growth on food. The microorganisms responsible for these alterations are generally referred to as deteriorating microorganisms.

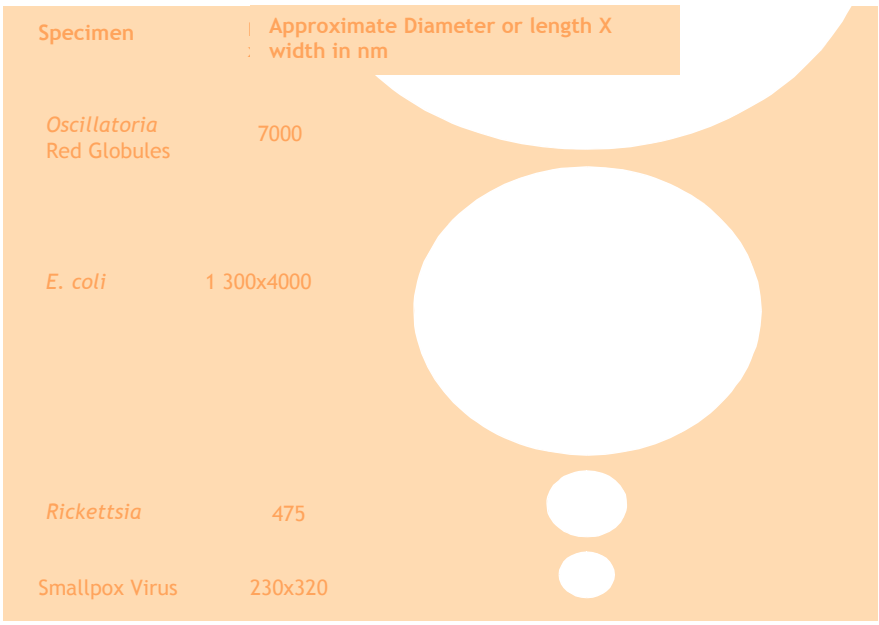

Figure 1 - Sizes related to some microscopic specimens. (1 um = 1000 nm) Adapted from: Prescott, et al (2004)

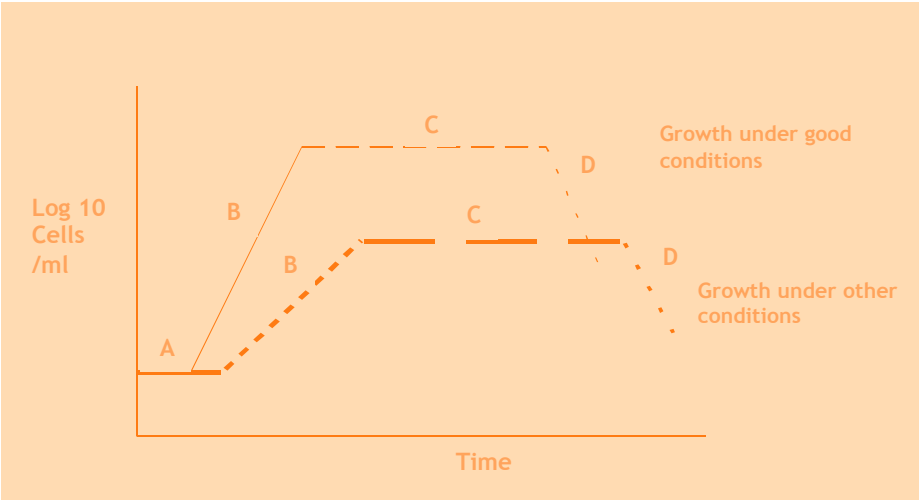

Figure 2 - Microbial growth stages in a liquid environment. A - lag stage, B - Log stage, C - stationary stage, D - Death stage

3 Factors that influence microbial growth

Just like all living beings, all microorganisms require a set of factors that allow them to grow/live in certain environments. These factors are obviously different from microorganism to microorganism. So, generally, bacteria require different environments from yeasts and these require different environments from molds, etc. Within each of these groups there still exist differences from specie to specie. The various factors that influence the growth of microorganisms in foods are generally designated as **intrinsic and extrinsic factors.** The first correspond to physical-chemical characteristics of the food while the second correspond to storage and environment conditions. Aside form these, there are still factors that have to do with the microorganisms own characteristics that are designated as implicit factors. The various factors are going to make a selection over the initial microbial flora, benefiting some species in detriment of the other. The manipulation of these factors allows us to obtain products with a longer shelf life and superior microbiological quality.

3.1 Intrinsic factors

Intrinsic factors are those that are related to the physical chemical characteristics of food.

As previously mentioned, these factors have a preponderant action over microbial growth, because almost all foods constitute for most microorganisms a more or less favourable environment to their growth. Like so, the type of nutrient content, pH, water activity, and oxygen are intrinsic factors that generally have greater influence on microbial growth in foods.

3.1.1 Nutrients

The more or less contents in proteins, sugars and other nutrients are going to determine what type of microorganisms are, preferably, able to grow on that food. The presence of vitamins, amino acids, etc., is going to allow the growth of some of the most demanding organisms, nutritional wise. Generally, molds are the least demanding nutritional wise, followed by yeasts and then by bacteria.

3.1.2 pH

pH measures the acidity of a food (or other product) and varies on a scale form 1 to 14. The following is considered:

Acid
Substances with a pH level between 1 and 6 (for example: lemon, vinegar, most fruits);
Neutral
Substances with a pH level close to 7 (for example: water);
Alkaline or basic
Substances with a pH level between 8 and 14 (for example: detergents, soaps, caustic soda).

PH levels vary with the amount of acid or basic compounds in an environment.
Consequently, the higher the amount of acid substances in a food, the lower the pH level which means the more acid the food is.
It is empirically well known and used the action of this factor over the growth of microorganisms in food.
Acidification has been largely applied in the food industry and even at the domestic level, as a method able to increase the foods shelf life.
Pickle production and other acidified vegetables are fundamentally based on the inhibition of microbial growth due to the use of a low pH level.
In food microbiology, it is well known that certain microorganisms only develop within certain pH levels (table I). So, with this knowledge, and the knowledge of the approximate pH levels of various types of products (table II) it is possible to foresee which microorganisms can be present in certain foods.

It is convenient to refer that the pH level not only affects the growth of microorganisms in food, but also the survival rate during storage and diverse conservation treatments.

Table I - pH level interval for the growth of some microorganisms

Microorganism	Minimum pH	Optimum pH	Maximum pH
Mold	1, 5 to 3,5	4, 5 to 6,8	8 to 11
Yeast	1, 5 to 3,5	4 to 6,5	8 to 8,5
Bacteria (most)	4,5 to 5,5	6,5 to 7,5	8,5 to 9
Lactic Bacteria	3 to 5	5,5 to 7,5	6,5 to 8

Table II - Approximate pH levels of some food products

Product	pH	Product	pH
Egg whites	7,5 to 9	Corn	7 to 7,5
Egg yolk	6,1	Potatoes	5,3 to 5,6
Shellfish	6,8 to 8,2	Carrots	5,2 to 6,2
Fish (most)	6,3 to 6,8	Onion	5,3 to 5,8
Fresh milk	6,3 to 6,5	Tomatoes	4,2 to 5,8
Butter	6,1 to 6,4	Oranges	3,6 to 4,3
Chicken	6,2 to 6,4	Grapes	3,4 to 4,5
Pork	5,3 to 6,4	Apples	2,9 to 3,3
Beef	5,1 to 6,2	Lemons	1,8 to 2,4

3.1.3 Water activity

Water, as we know, is essential to life. There are no known living beings that don't depend on water. However, there are beings with diverse levels of tolerance to more or less water availability. Therefore, the amount of water in a food is one of the main factors that determine the facility that a certain microorganism can grow on it, and consequently deteriorate it. Actually, the amount of water available in a food is responsible for major part of the development of microorganisms on food. From earlier days, man has used methods that increase the shelf life and microbiological stability of foods, by reducing the amount of available water. Ancestral food preservation methods, such as drying, salting and the addition of sugar were based on the basic principle of reducing the amount of available water. The greater the amount of sugar or salt in a food, the less quantity of available water will exist and the possibility for microbial growth will also be smaller.

Just like the other factors, the minimum demand of available water for each microorganism is different. Generally, molds and yeasts bear environments of less water available than do bacteria. We should note, that just because microbial growth isn't possible on a certain food, doesn't mean that microorganisms aren't present. A great number of microorganisms are capable of maintaining themselves in a latent state on foods with lower water levels, which after rehydration can regain their growing ability. In this case, foods with sugar, salt and flour are excellent sources of contaminating microorganisms during the preparation of other foods.

3.1.4 Available Oxygen

The amount of oxygen in an environment has also influence on the type of microorganisms that can grow in a certain food and on the rate of their multiplication.
The use of air tight packages results in the reduction of available oxygen in food.
Vulgar acts used in food manipulation and/or processing, in one way or another, end up influencing the availability of oxygen. For example: Boiling results in the loss of dissolved oxygen, on the other hand, mincing meat results in increment of the oxygen concentration in the food.

3.1.5 Other factors

Other factors exist rather than the referred intrinsic factors that in a more or less efficient way influence microbial growth on food.
Generally, the presence of biological structures (skin, tegument, shells, peelsA, etc.) do not impede the entrance of microorganisms in food, they just make it difficult to occur a deeper infection, if completely intact. Cleary, this situation changes when these structures suffer damage during harvesting, transportation, storage or processing.
Microbiological stability of some foods depends on the presence of some natural substances that are found on these products. It is well known the effect that garlic has on microbial growth. Garlic contains a substance (alicin) capable of inhibiting the growth of some deteriorating bacteria (using garlic to preserve meat with a garlic wine marinate). The same happens with other products (lysosine in egg whites; lactoferrin in milk; eugenol in Rye – used by dentists; etc.).

3.2 Extrinsic factors

Extrinsic factors are those related food storage conditions and environment conditions

Just like the intrinsic factors, these also play an important role in the food preservation. In fact, these are generally the factors that we most manipulate and control on a daily basis: temperature, humidity and oxygen.

3.2.1 Temperature

Temperature is one of the most relevant factors on microbial growth. If we think about food safety, this definitely ends up being the most important of all factors. When considering foodborne intoxications, it is not by chance that the use of risk temperatures during the conservation of food/meals, as well as the use of improper temperatures during food preparation/processing (under processing) are pointed out as being the main causes of the occurrence of food intoxications.

Similar to all the other factors, all microorganisms require a certain temperature to grow at maximum speed; this is designated as optimum or ideal temperature. Frequently, microorganisms are grouped or classified according to their optimum temperature of growth:

THERMOFILE
Reach their optimum (ideal) temperature at 40 ºC to 65ºC
MESOFILE
These are microorganisms that prefer average temperatures. Optimum (ideal) temperature is between 20 ºC and 40ºC;
PSICROFILES
Are microorganisms that grow well at 0ºC, although their optimum (ideal) temperature is 15ºC or under.
PSICOTROFIC
Are microorganisms that grow well at temperatures between 0ºC and 7ºC, although their optimum (ideal) temperature is situated between 20ºC and 30ºC.

Microbial growth is slower, if the temperature to which they are exposed to decreases or increases in relation to the optimum temperature. Microbial growth stops when temperatures are under the minimum value or above the maximum value, but do not always result in the death of the microorganisms. As long as very high temperatures (used during cooking food) allow the destruction of a major part of microorganisms, the same doesn't happen at low temperatures. Freezing does not cause the destruction of microorganisms; it only maintains them in an inactive state (figure 3). Unfreezing will eventually allow them to develop. Therefore, the correct use of temperatures during the maintenance food and food products is fundamental for its preservation and longer shelf life.

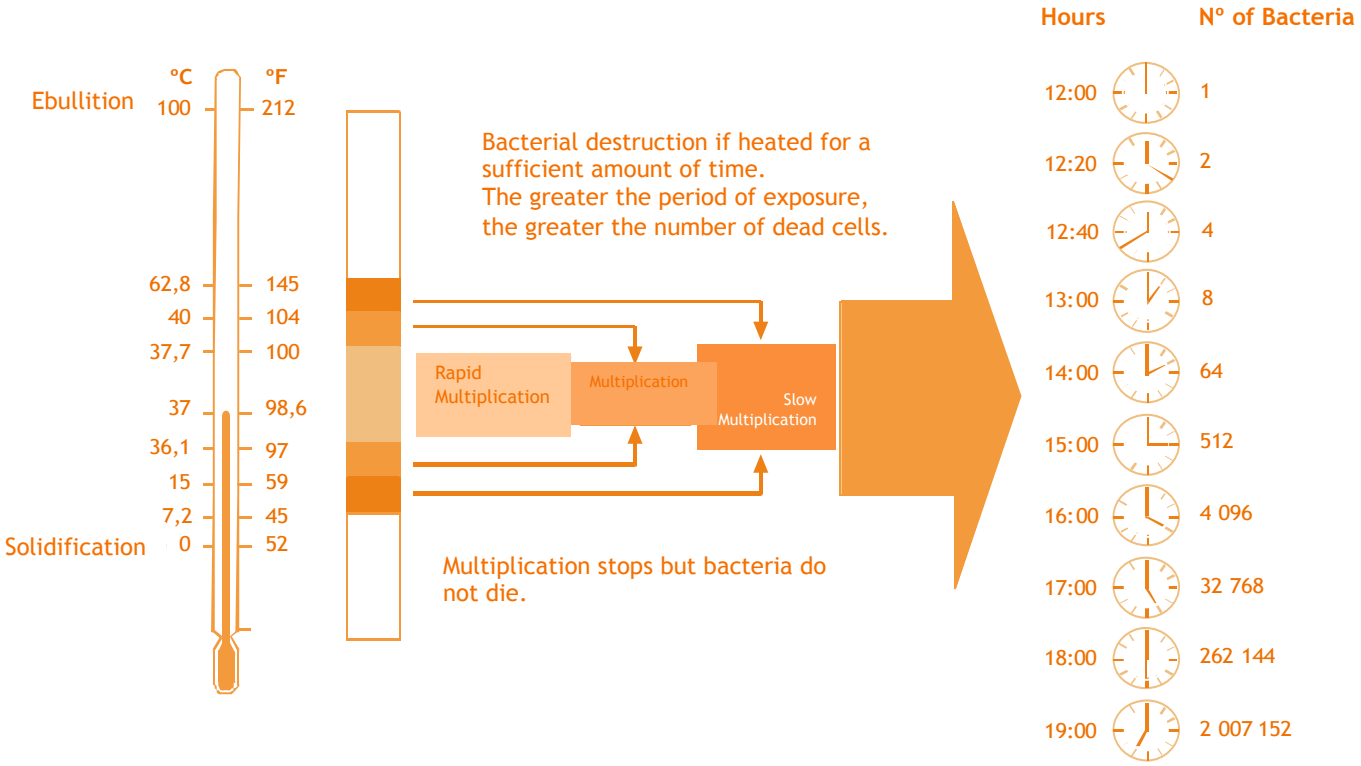

Figure 3 – Illustrative representation of the effect of temperature and time on microbial growth. Safe and danger temperatures for food products.
Adapted from: Jay, J., 1996.

Heat kills microorganisms, but cold only inhibits or delays their growth.

3.2.2 Relative Humidity

A very high relative humidity level favours microbial growth, especially those that are found on surfaces. For some time now, dehydration and drying techniques have been used to maintain foods for longer periods of time. However, foods must be stored in low relative humidity conditions; otherwise, the humidity that is present in the surrounding environment will eventually end up increasing the amount of water in foods, and consequently, increase the risk of microbial proliferation.

3.2.3 Oxygen (atmosphere)

Oxygen is fundamental for the survival of many organisms. However, other organisms that do not tolerate the presence of oxygen exist and can die if exposed to it during some time. In the first case, the organisms are designated as **aerobic** and in the second case as **anaerobic**. Other organisms exist in the middle of these two extremes that are capable of growing in the presence or absence of oxygen; some even grow better if they are before a higher concentration of carbon dioxide, etc. The knowledge about how modifying the surrounding atmosphere can cause negative effects on some microorganisms and positive on others, has lead us to use, for some years now, modified atmosphere, controlled atmosphere or vacuum food packages to keep products fresh. Today, it is vulgar to find fresh produce (meat, vegetables, etc.) in packages with a “modified atmosphere” indication. These techniques allied to refrigeration, have a positive effect on the increase of the products shelf life by delaying the proliferation microorganisms.

3.3 Other factors

There are many possible ways to avoid or reduce microbial growth on foods. However, what is the most effective procedure? If manipulating some factors does not bring on great complications, other factors are not always possible to manipulate (at least without having to profoundly modify the food). Generally, **microorganisms present in certain foods, are never or almost never submitted to**

the "pressure" of selection based on only one factor. So, a certain food can have an average pH level, but has a low level of available water and is stored in a vacuum package and is also refrigerated. If there exists microorganisms capable of growing easily at that pH level, they probably won't be able to do so with the amount of available water, or with the present oxygen concentration or with the storage temperature used.

Therefore, the existing joint action of various factors is going to make a selective action over the present microorganisms, simultaneously. This joint action was denominated as "the hurdle concept", which can be compared to a hurdle competition, where not every athlete is capable of overcoming all hurdles (obstacles) (figure 4).

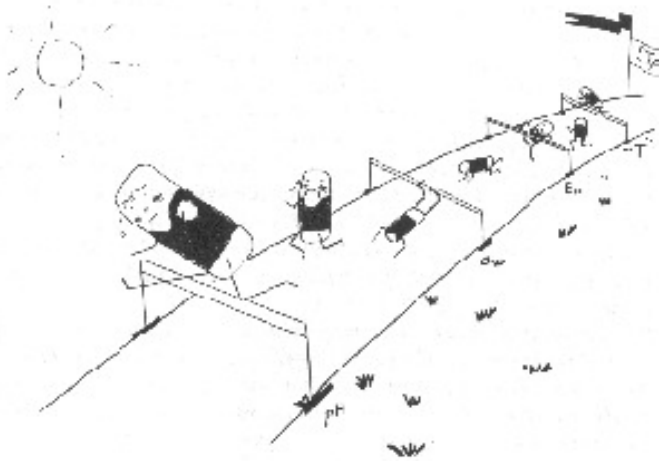

Figure 4 – Illustration of the "hurdle concept" applied to food preservation. Each factor (pH, T, etc.) constitutes a barrier to microorganisms. Only a reduced number of microorganisms will be capable of overcoming all barriers. Adapted from: Adams. M. R and Moss, N.O, 1995.

4 Main groups of microorganisms

The concept of microorganism was previously defined and talked about. Now, we intend to define and characterize the main groups of microorganisms, especially those that are most important to Food safety: Bacteria, molds, and yeasts.

4.1 Bacteria

Among all types of microorganisms that intervene with food, bacteria make up the most important group due to their diversity and to their actions of greater frequency.

In the presence of favourable conditions, they are capable of quickly multiplying on the foods nutrients, by causing alterations or by just simply dwelling on it and sometimes cause intoxications. Bacteria are unicellular organisms that come in various forms (figure 5). The most common forms are:

Spherical: called ***cocci***
Rod-shaped: called ***bacilli***
Spiral-shaped: called ***spirilla***

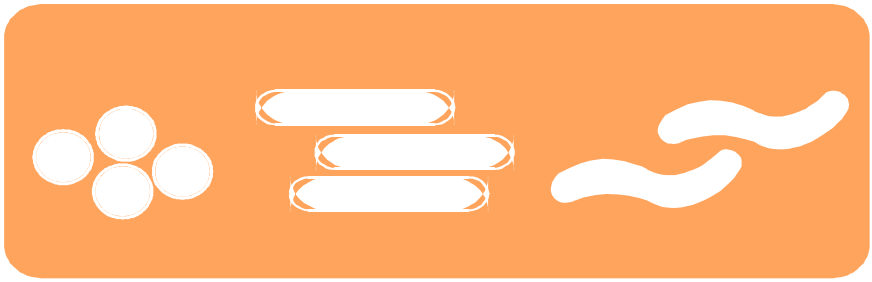

Figure 5 – Illustration of the three main forms of bacteria: cocci, rod-shaped and spiral-shaped.

Regarding reproduction, bacteria reproduce by binary fission which is the division of the cell into two equal parts. In certain situations, some bacteria (*Clostridium, Bacillus*) are capable of forming highly resistant structures to temperatures normally used during cooking and conservation treatments. These structures are called endospores – these are formed when the cells are in the presence of unfavourable growing conditions (lack of nutrients, etc). *Bacillus cereus* endospores are capable of resisting over an hour in boiling water; these represent the most effective resistant structures known amongst all livings beings. Once the endospores encounter favourable growing conditions, they will germinate and form cells identical to the ones that originated them.

4.2 Molds and yeasts

Although they present very different features, molds and yeasts belong to the same big taxonomical group – fungi. Mushrooms also belong to this kingdom.
The action of these microorganisms is very important to food, although some may produce toxins (mycotoxins) they have a strong capacity to decompose most foods. However, their action also brings benefits to man. They are used in the production of some foods (bread, beer), in the quality of other foods (Roquefort, Gorgonzola, Stilton, Camembert and Brie cheeses) and some are edible (mushrooms) (figure 6).

Regarding their structure, molds are characterized for presenting a more or less filamentous aspect (figure 7).

Yeasts or leveduriform fungi are unicellular microorganisms of a more or less spherical form. Although there are no known cases of food intoxications caused by any species of yeast, their proliferation on food can cause it to deteriorate. They are microorganisms used from ancestral times (their existence wasn't yet acknowledged!!!) in the fabrication of various food products (bread, beer).

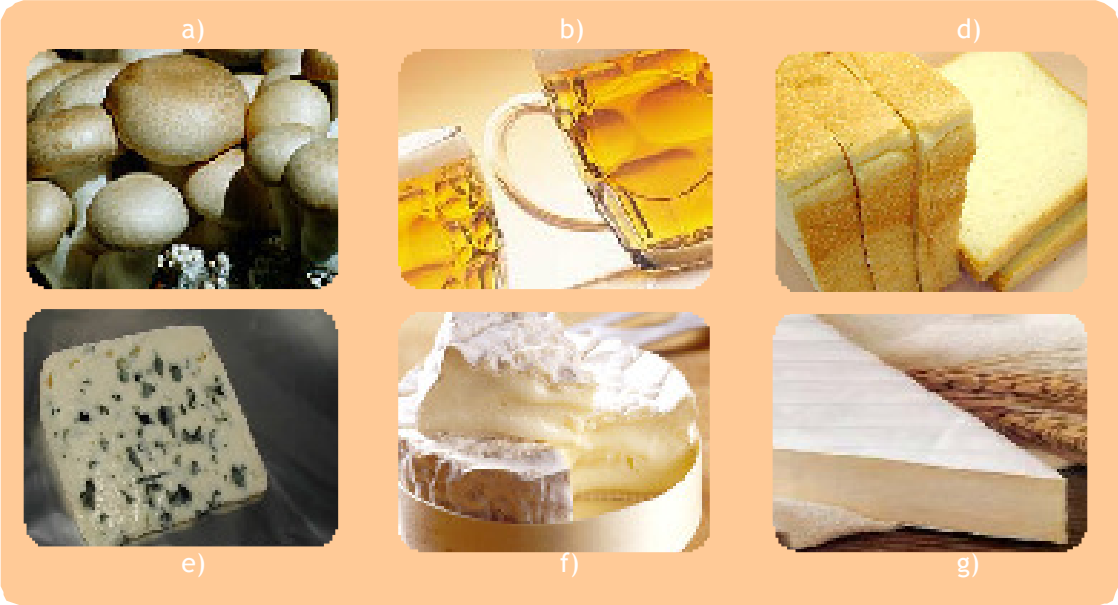

Figure 6 - Some uses of fungi. a) Edible mushrooms; b) beer; c) bread; d) Roquefort cheese with blue mold; e) and f) Camembert and Brie cheese with white mold (respectively).

Figure 7 – Pictures showing mold on foods. Notice the different colours because of the formed endospore.

5 Microorganisms and food

Microorganisms can have various effects on food, as mentioned before. We also talked about what main factors affected microbial growth on food, but where are they from? How do microorganisms “appear” on food?

Microorganisms on food have many different origins: air, soil, water, handlers, utensils, equipment and obviously products themselves or raw material used in their fabrication.

Water, air, soil, and food themselves, contribute with their own natural microflora. Each one of these environments presents microflora of different compositions, in quantity and in diversity, but many times are interconnected with each other.

5.1 Soil

Soil itself is an environment with various microenvironments (sandy and dry soils have different microflora from wet and fertile soils). It’s an important source of spore forming bacteria (*Bacillus, Clostridium*), of fungi and yeasts. When soils are fertilized with animal manure, fecal microorganisms (present in warm blooded animal intestines) such as coliforms, salmonella, enterococci, etc. are added to the natural flora. These microorganisms are easily passed to the products cultivated there, especially roots, tubercules and ground level vegetables. On the other side, soil microorganisms can be transported in dust by wind, rain or water form watering and contaminate fruit and other vegetables. Soil microorganism dissemination can also be carried out by animals (adhered to hooves, fur, feathers, etc.), insects, etc.

5.2 Water

Water holds microflora whose composition reflects its origin and level of pollution.
In a Public health point of view, the presence of fecal microorganisms deserves particular attention because the presence of these microorganisms may indicate the presence of pathogenic microorganisms, which through this source can easily propagate to other foods. That is why it is important to use good microbiological quality water, not only for washing or

preparing foods or beverages but also for washing utensils used to prepare and/or hold foods. In fact, according to some authors, one of the main sources of cooked food held in ice (for example, seafood) contamination is the ice itself, due to the use of bad quality water for its preparation.

In order to avoid the risk of food contamination with water microorganisms, it is sufficient to use good microbiological quality water, while:
- washing food;
- Preparing food and beverages;
- Making ice or freezing water to cool/conserve food.

Table III - Effect of washing on the flora of vegetable products.

Type of product		Num. of microorganisms
Tomato	Not washed	> 1 000 000/ cm2
	Washed	400-700/cm2
Collards	External leaves not washed	1 000 000 – 2 000 000/g
	Internal leaves washed	200 000 – 500 000/g
	Internal leaves	100 – 10 000/g

Data from: Jay, J.M, 1996 and Lacasse, D., 1995

5.3 Air

On the contrary to what we think, air is not a direct source of microorganisms. It is, however, an excellent conveyer of microorganisms from other sources. The composition of air does not allow the development of microorganism because they can't find any nutrients in it. So, what we find in air are microorganisms from the surrounding environment. It's not difficult to foresee that microorganisms found in kitchen air are different form the ones found in the air of an office of any business. Some activities or gestures carried out by man are the main cause for the "introduction" of microorganisms in air. Simple gestures like shaking your head – especially with long free hair, sneezing or coughing, transfer to the air many microorganisms of the human flora. Activities related to production of vegetable products also transfer to the air microorganisms of different origins: tilling lifts dusts; watering – especially by aspersion – forms drops of water containing microorganisms form soil and water; etc.

Although air does not contain its own flora it is one of the main transmission vehicles of microorganisms to food, as previously mentioned, especially to cooked food.

In order to reduce the contamination of airborne microorganisms, all we have to do is follow some simple rules:
- Keep food covered every time possible;
- Regularly, remove dust from surfaces;
- Avoid keeping food in places where there is a lot of air agitation (ventilators, air currents, etc);
- Reduce the air load (for example, by filtration);
- Avoid over crowed places.

5.4 Food

Each product, whether of animal or vegetable origin, holds characteristic flora, that essentially depends on the environment where it was brought up or produced. Generally, internal vegetable product tissues contain few microorganisms. On the contrary, external tissues carry a very extended and varied load of microorganisms, due to greater exposure to air, soil

and other sources of microorganisms.
Normally, in healthy animals, the interior of their meat is exempt form microorganisms. All animals have biological systems that limit microorganism access to the interior of the meat. During slaughter access is facilitated. Microorganisms are mainly found on the surface – skin, fur, feathers, scales, etc. and in the digestive system (figure 8). Following slaughter, the removal of skin, feathers and entrails constitute the main contamination risk points. Removing the entrails requires special precaution due to the mass presence of fecal microorganisms.

5.5 Handlers

Handlers play an important role regarding the flora of food and food products. Along with air, they constitute one of the main sources of food microorganisms. Just like animals used as a food source, man also possesses a specific flora adapted to various environments that are found on the human body. *Coliforms* and *Staphylococcus aureus* are the main microorganisms related to food contamination by man. These microorganisms are originated from fecal matter (coliforms) and handlers´ skin. Special hygiene care is required when handling cooked food or food that is going to be consumed raw.

5.6 Utensils and equipments

Utensils and equipments don't have their own microflora. The microflora they possess is a reflex of cleaning and maintenance care that they undergo.

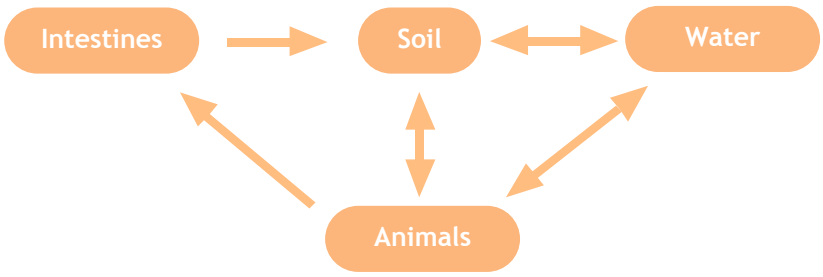

Figure 8 – Main sources of microorganisms in food. The illustration shows the means of infection among foods of animal origin and the two main reservoirs of microorganism.

Considering that microorganisms easily adhere to materials, the contact of food with poorly clean surfaces – work areas, wall, etc. – substantially increases the microbial load. Poorly clean machines and accessories are inevitably contamination sources. The same happens with other utensils, knives, cutting boards and recipients. It is fundamental that the same utensils are not used to manipulate or store different foods in order to avoid **cross-contaminations**.

5.7 Cross-contamination

Cross contamination occurs when microorganisms present in raw food, utensils and contaminated surfaces are transferred to cooked or washed foods or even to clean surfaces.

This transfer can occur through utensils, hands, cloths, etc. The presence of pests, especially flying insects, along with the use of unsealed food containers, constitutes great risk to the occurrence of cross contaminations. Like this, a clean surface or uncontaminated food can be contaminated by a microorganism brought from another place.

It is of great importance to avoid cross contamination between raw foods, which are almost always contaminated, and cooked foods. Everything that comes into contact with raw foods (utensils, equipments, hands, etc.) must be thoroughly washed before being handled with cooked foods.
The utensils and equipments used to store, prepare or serve foods must be thoroughly clean and hygienized. They should be correctly stored and preserved from the surrounding environment, in order to avoid contamination from airborne microorganisms.

Some examples of cross-contamination:

Raw food (without hygienization or *"in natura"*) and ready to eat food:

Example:
- Uncovered raw meat stored in the refrigerator with ready to serve hygienized salad. The air that circulates in the refrigerator can transfer microorganisms form the meat to the salad.

6 Risks and hazards

In food safety the terms **“Risk”** and **“Hazard”** have different meanings from the one we usually use, where normally they end up being considered synonyms.

In food safety, “hazard” means a chemical, physical or biological agent with potential to contaminate food.

So, there exist various types of risk: microbiological, chemical, physical, etc. Table IV presents various groups of hazards related to food safety, and gives some examples for each category.

Hands, utensils or equipments that are in contact with raw food (without hygienization or *“in natura”*), com into contact with prepared food:

Example:
- The utensil used to put raw meat in the frying pan cannot be the same one to take it out;
- The hand that handled raw meat cannot be the same hand that touches the coffee strainer;
- Bowl used to beat raw eggs cannot be the same to put ready food in.

“Risk” is the likelihood of occurring “hazard”.

For example, holding cooked food at room temperature constitutes “risk”, because there is the probability of occurring microbial growth (microbiological hazard).

The main risk factors related to microbiological hazards (for example, food contamination by action of bacteria) are:

- Insufficient personal hygiene care;
- Insufficient hygiene care while handling products;
- Inadequate binomial time/temperature for product conservation ;
- Humidity conditions susceptible to microbial development;
- Practices that favour cross contaminations (examples: storage of raw and cooked products without a physical barrier separating them);
- Inadequate hygienization of establishments, equipments and utensils;
- Inadequate pest control.

Concerning chemical hazards (for example, detergent residue on food) we have as main risk factors:

- Poorly designed facilities that favour the permanence of chemical residues (examples: surfaces that do not allow rinsing and drainage of detergents);
- Insufficient equipment maintenance;
- Practices that favour cross contamination (examples: detergents and food products arranged in the same place without a physical barrier separating them);
- Inadequate equipment, agents and/or cleaning procedures;
- Incompliance with cleaning and disinfection procedures defined on the Hygienization plan.

Regarding physical hazards (for example, presence of a piece of glass in food) the main risk factors are:

- Insufficiencies at the infrastructure of facilities level;
- Presence of strange objects to the activity in the facilities;
- Poor cleaning and/or conservation state of Facilities/vehicles/equipments /utensils.

Table IV - Classification of hazards related to food safety

Types of hazards	Examples of hazards	Examples of associated foods	Potential illnesses
Microbiological			
Bacteria	- *Salmonella*	- Eggs, poultry, raw milk and milk products	- Salmonellosis
	- *Campylobacter*	- milk, cheese, ice cream, salads	- Campylobacteriosis
Virus	- Rotavirus	- Salads, fruit and appetizers	- Diarrhoea
	- Hepatitis A virus	- Fish, seafood, vegetables, water, fruit, milk	- Hepatitis A
Parasites	- Toxoplasm	- Pork, yearling lamb	- Toxoplasmosis
	- Giardia	- Water, salads	- Giardosis
Prions	- BSE agent	- Specific bovine risk materials	- Variant of the Creutzfeldt-Jakob disease
Chemical			
Natural toxins	- Aflotoxins	- Nuts, corn, milk and milk products	- Cancer, congenital malformations, premature births, alterations of the immune system; nervous system degenerative diseases; hormonal alterations, dysfunction of various organs; fertility alterations; muscle and bone diseases; behaviour alterations.
	- Solanin	- Potato	
	- Marine toxins	- Shellfish, seafood	
Pollutants of industrial origin	- Mercury, Cadmium and lead	- Fish	
	- Dioxins, PCBs	- Fish, animal fat	
Contaminants that result from food processing	- Acrilamid	- French fries, coffee, cookies, bread	
	- Polycyclical aromatic hydrocarbons	- Smoked products, vegetable oils, grilled food	
Pesticides	- Insecticides, herbicides, fungicides	- Vegetables, fruits and fruit products	
Veterinary medicines	- Anabolics, antibiotics	- Poultry, pork, beef	
Non authorized additives	- Sudan I-IV, for red (dyes)	- Sauces, spices	
Material in contact with food	- Aluminium, tin, plastic	- Canned or plastic packaged food	
Other	- Cleaning products, lubrificants		
Physical			
	- Bones, fish bones, glass, metal, stones		- lesions
Nutritional			
	- Excess salt	- Table salt, snacks	- Cardiovascular diseases
	- Excess fat	- Butter, fat meat	- Obesity
	- Excess sugar		- Diabetes
	- Allergens	- Cow milk, peanut, eggs, crustaceans	- Allergies

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